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ABSTRACT

Despite gains since 1970, women still make up only 15% of the science and engineering workforce in the United States. Nationally women constitute about 11% of the science faculty in professional ranks. A recent research study's dealing with the issue of women in science found that women's self-concept resulting from few faculty as role models, discouragement by less "A" grades, their distinct minority role, etc. are factors in lower participation in the sciences. This article reviews the situation of women at the University of Michigan and trends that may be occurring there. Several programs on different campuses, which are designed to encourage women to continue in the sciences by creating a more hospitable academic atmosphere are described. "Summerscience," a Michigan program aimed at keeping junior high and high school girls in the science track is described in an insert by Deborah Gilbert. Suggestions for how administrators and faculty can help improve the climate of instruction for women at the undergraduate level are presented. A list of 16 references and 9 related readings is included. (CW)

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IT OUGHT TO BE A HAPPY NEW YEAR

On the cover: *From* Judge Magazine, *November 19, 1898. Grant Hamilton used nursery rhyme imagery to make a simple point – corruption is bipartisan. Republican Boss Platt licks the platter of New York state patronage clean; seated is Democratic Boss Croker, his stomach bulging. (See "America in a Mirror: 150 Years of Caricature," p. 4).*

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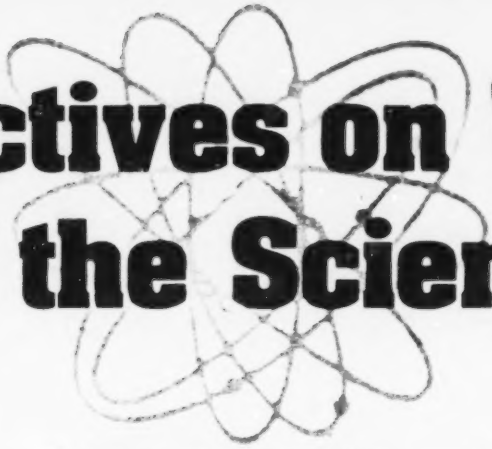
Perspectives on Women and the Sciences



by Barbara Furin Sloat

As a college student, I had no idea that I would go into the sciences—or that I would eventually be interested in the issue of women in the sciences. I went to Denison University from Youngstown, Ohio, intending to become a public school teacher, an acceptable career goal for young women in the 1960s and one encouraged by my parents, both public school teachers, themselves. For much of my time in college I thought of myself as an English major who just happened to love biology enough to take at least one science course each semester. It wasn't until well into my third year at Denison that I finally had to choose a concentration—a decision that entailed many sleepless nights. I finally chose biology, with the rationale that I could always read and write, but I would not be able to study and take courses in the sciences as easily once I left the college environment.

I was so busy taking English and science courses that I didn't have time for the education courses that would allow me to teach in the public schools. I had already decided to go to graduate school for the requisite master's degree in education when I saw a bulletin board notice about summer internships in the sciences, sponsored by the National Science Foundation (NSF) at various research universities. And so it was that I came to the University of Michigan, to spend six weeks in the Medical School's Department of Anatomy. There, for the first time, I was introduced to experimental work and encouraged to think beyond high school teaching. One thing led to another, and on the way to that putative master's degree, I spent a year in Belgium and became involved in the research on multiple forms of enzymes that would eventually lead to my Ph.D. thesis in the U-M's zoology department.

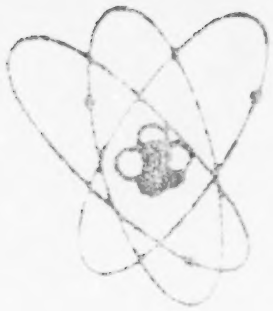
I recount all this to make the point that I came to study and work in science not because of pressure from family or teachers (in fact, I was more often questioned about my choices, especially during my undergraduate and graduate years), but because of genuine interest in and fascination for biology. This is what drives my interest in issues of women and science: I don't want to recruit scientists "out of the woodwork," so to speak, but I do want to encourage those with genuine interest to pursue and stay with their interests. It has been my experience that women do not get that kind of encouragement nearly often enough.

Throughout most of my educational and working career, I didn't think about the fact that I was "a woman in science." Actually, it wasn't until some years into my working life that I came to a real awareness of how few women there were around me—at Michigan, at Denison, at local and national conferences, and in the science classroom. I realized that I had never had a female science professor in either college or graduate school—nor even in high school; that I had not been encouraged toward graduate school or a postdoctoral position to the extent that my male peers had been; and that, especially in graduate school, I hadn't been expected to go on to be a "full member" of the scientific community as much as my male counterparts had been. I began to realize that, despite my high performance level, an undercurrent always resurfaced, constantly reminding me that I was "working too hard," or that I would "get married and have children anyway." Shortly after obtaining the Ph.D., I was told by a departmental chair at Michigan that "of course you can't expect to earn as much as a male would; after all, your husband has a good job, doesn't he?" Twenty years later, I am delighted that students are alert much earlier than I was to the attitudes underlying such discouraging and destructive comments.

In the past few years, the challenge for me has changed from initiating practical programs to increase the numbers of women in the sciences to attempting to determine *why* there are still so few and *what* can be done to make a difference. I find myself trying to understand science as an institution: the social structures of the scientific workplace, its reward systems, and the means by which success is achieved within its framework. And I have begun to realize that science is an endeavor in which gender differences and role stereotyping show up in especially striking ways. Indeed, the very association of science with masculinity is deeply rooted in our culture and in the structure of science itself. In asking how to increase the numbers of women in science, I am convinced that we must first explore the ways in which women feel like "outsiders" to science and the ways in which their experiences in the scientific disciplines differ from men's. Only when this larger framework is better understood will we be able to make inroads to change the situation, by, I believe, changing the institutions in which our students find themselves.

And so I have come out of the lab—out of all that scientific training and experimental work—with an expanding view of the complexities of human experience and, paradoxically, a much greater sense of the potential of opening science to a broader range of people. And I have discovered that the evolution that has occurred in my own thinking in recent years is paralleled by a larger movement in the country as a whole; I perceive that a new attitude is beginning to filter through, and I believe that more of us, as educators and parents, should be aware of it.

The bad news is that despite gains since 1970, women still make up only 15 percent of the science and engineering workforce in the United States (where they are disproportionately concentrated in psychology and the life sciences; only 4 percent of the nation's professional engineers were women in 1987, the most recent year for which data are available). At Denison, my



alma mater, women constitute 17 percent of the science faculty in professorial ranks—compared to a national average of about 11 percent.

At the University of Michigan, the numbers are even lower. In the College of LS&A, where virtually all of our undergraduates attend classes, only 8.3 percent of the current professorial faculty in biology are female (6/72); 4.9 percent in chemistry (2/41); 4.0 percent in geological sciences (1/27); 3.0 percent in mathematics (2/67); 3.5 percent in physics (2/57); and none in astronomy. History is in the making, however: this year the physics department has its first (two) women in regular faculty ranks, an encouraging development that may portend future changes in the College.

The numbers for students look better: In LS&A, for 1988-89, 20 percent of undergraduate degrees in astronomy were awarded to women (1/5); 40 percent in biology (100/250); 36 percent in chemistry (16/44); 30 percent in geological sciences (3/10); 43 percent in mathematics (30/70); and 5 percent in physics (1/19). The questions to ask, however, are: Where will these students be going? What are their aspirations? Will they have a chance of fulfilling them? What will they have learned here to prepare them for what lies ahead?

The good news is that the issue of underrepresented groups (women and minorities) in the sciences is now becoming one of national discourse, fueled by projections of a serious shortage of scientific personnel in the decades ahead and cries of national need and international competitiveness. We will hear more and more about this, largely because demographic trends make it abundantly clear that this country is facing a significant drop in the number of white males of college age, who have traditionally made up the pool from which scientists and engineers are drawn; (by 2010, white males will make up less than one-third of the college-age population). Even now, we have passed the peak of U.S. graduate students available from traditional pools and, if nothing changes, are headed towards a potential decrease of 40 percent by the year 2000.

Photo by Don Goings

Barbara Sloat talks with students Joshua Worth and Kristin Genoa.

And so we ask: "Who will do science in the years ahead?" It is apparent that women and minorities form the greatest potential pool from which to repair the projected "shortfall": they have been greatly underrepresented in the scientific workforce to date, and they represent an increasing percentage of available undergraduate and graduate students and potential workers; (by the year 2000, 85 percent of the net additions to the American workforce will be women, members of minority groups, and immigrants; only 15 percent will be white men.) Insofar as this attention to national need brings us added resources with which to close the gender gap in the sciences, it is all to the good. My own concern, however, has less to do with projections of national need than with the memory and knowledge of the countless women with genuine interest in the sciences who were, and are, dissuaded or discouraged from its pursuit. It is *their* contributions, born of real and sustained intellectual interest, that we want to encourage and that we so badly need.

What is encouraging is that at *this* time prominent scientists and policy makers—including members of the National Academy of Sciences and the American Association for the Advancement of Science (AAAS)—are talking and writing about the underrepresentation of women in the sciences. The topic is no longer just the province of small groups on individual campuses (often generated, I might add, through women's centers and women's studies units). Because it may translate into funds for programs and support services, this new attention is very important. But what is *really* significant

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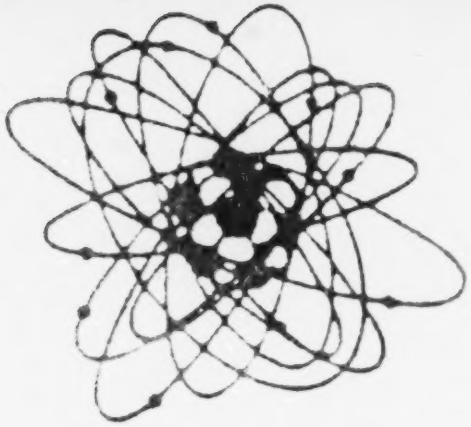


about the current "women in science" discourse is its apparent shift in tone. No longer is there simply a call to increase the numbers of girls and women in the sciences—by making sure that they take more mathematics and science courses, for example, typical responses of the past. Rather, I detect growing recognition that women's experience with science differs from men's and the beginnings of attempts to understand *how* that is so; there is even a call to *reshape the institutions* in which young women find themselves. I see this, coming now from nationally prominent scientists, administrators, and policy makers, not just from those of us in the ranks, as a sea change in attitude.

It is significant that the 1988 Presidential address at the American Association for the Advancement of Science meeting dealt with the issue of women in the sciences. The address, given by outgoing president Sheila Widnall, Professor of Aeronautical Engineering at MIT, was not only a major address at the conference: it was also published as the lead article in *Science*, one of the world's premier scientific journals ("Voices from the Pipeline," September 30, 1988). In it, Widnall cites data from a recent Office of Technology Assessment (OTA) study that followed 2,000 female and 2,000 male students from age 14 through attainment of the Ph.D. degree. The study discovered two major problem points on the way from junior high school to advanced degrees in science: the early college years, when students decide on a possible major or career choice, and, later, as they negotiate the graduate school system. It is during these years that science seems to lose so many talented and interested young women, and it is at these points that we can, perhaps, make a large difference. Indeed, young women who have gotten as far as college and graduate school with their interest in science intact deserve all the help and support we can offer.

The OTA data—and that of others' and my own experience—indicate several findings that may describe a cycle of cause and effect, with the result that one-third as many women as men graduate with B.S. degrees in science and engineering (recall that the numbers of women are also skewed in favor of psychology and against the physical sciences and engineering).

1. Women often make the decision to drop their interest in science concentrations after the first semester undergraduate course in a science. The introductory courses, especially at many large research institutions, apparently serve to discourage undergraduate students at a time when they most need support.

2. Women students are a distinct minority at every level in many scientific disciplines, and especially so in upper-level or graduate courses; consequently, a "critical mass" of female peers is often lacking in courses and departments.

3. Because women have few female teachers or faculty to serve as role models in the sciences, they rarely have an opportunity to see women who have gone before them to interesting, vital careers in these disciplines.

4. Women ask fewer questions in undergraduate courses and engage less often in debate with other students and faculty members.

5. Women are more discouraged by less than "A" grades in the sciences than men in the same classes, and they are more likely to blame their own "lack of talent" rather than problems in the classroom or teaching climate as the cause of their perceived unsatisfactory performance.

6. Women struggle with self-doubt in choosing a science major, apparently believing that they must choose between science and a "normal" life.

It is relevant to note that all of these factors suggest something about young women's self-concept or self-image. A study reported at a 1988 conference sponsored by the U-M Women in Science Program and the American Association for the Advancement of Science indicated that while the self-esteem of men is raised in college, that of women is *lowered*. Despite objective records of similar performance and virtually equivalent GPAs, women's self-estimates of their intelligence relative to their peers diminished during college, with a particular loss of self-esteem reported in the sophomore year.

Recent surveys of male and female graduate students in scientific and engineering departments at Stanford and MIT report similar findings for students who go on to graduate school. In essence, the surveys indicate that men and women respond differently to the pressures of graduate school and often have different images of themselves and of their advisors' perceptions of them as graduate students.

The Stanford study concluded that women were indistinguishable from men in objective measurements of preparation for graduate education, in career aspiration, and in measurable performance in graduate school. Typically, men scored higher on the Graduate Record Exam's math section, while women scored higher on the verbal and analytical portions and had a higher undergraduate grade point average. The grade points of the male and female students as graduate students were essentially identical.

However, women and men differed significantly in their *perceptions* of their preparation for graduate school, in their perceptions of how their advisors viewed them, in the pressures and roadblocks they experienced, and in the ways they coped with problems. In *all* the questions in the Stanford survey that measured level of self-confidence in the academic setting, women students scored consistently and, sometimes dramatically lower than men. As Widnall points out, the white male students understandably "benefit from the self-reinforcing confidence that 'they belong,'" and it is prob-

"Summerscience" urges young women to try science

"Summerscience," a program aimed at keeping junior high and high school girls in the science track, began on June 16 last summer as 45 ninth grade girls from across the state settled into rooms on the sixth floor of Mary Markley Residence Hall. Selected from among 350 applicants, the young women spent two weeks working on laboratory and computer projects designed to interest them and to reinforce their belief in their scientific competence.

The young women raved about the program in their final evaluations. "I enjoyed the feeling of belonging to a group of people as 'special' as [those in] this program," wrote Ivette Zaida Hernandez of Detroit's Earhart Middle School. "If I could do it again, I would jump at the opportunity," said Tiffany J. Brown of Canton's East Middle School.

The ninth graders experimented with thin-layer chromatography, soldered circuits to make digital clocks, designed watershed models, and analyzed water samples. They visited a T-shirt silk-screening factory to find out about industrial operations, analyzed chemicals that had been "processed" by yeast, and built models of molecular reactions and then "recreated" their findings in beakers.

They also experimented with MacPaint computer graphics, toured the women's athletics facilities, and debated scientific ethical issues with such passion that minority opinions were presented as part of group reports.

Cinda Sue Davis, director of the Center for Education of Women's Women in Science program, says that "Summerscience" was developed to

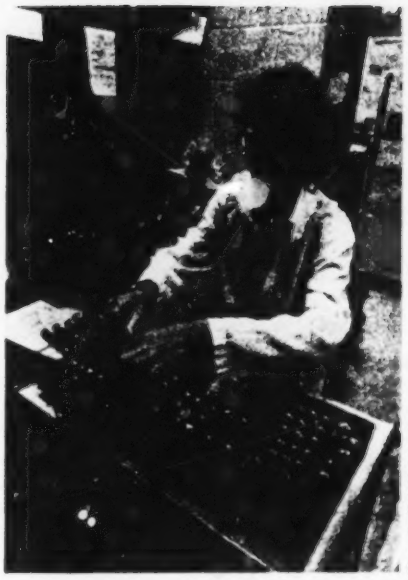


Photo by Bob Kalmbach

able that their self-identification with their predominantly white male mentors serves to reassure them that graduate school is a step on the way to a productive career in science. For women students and minority students, who lack models of those who have gone before them, the environment is clearly not as reinforcing.

Graduate students at MIT's School of Science were surveyed both by the Graduate School Council and by a presidentially appointed Committee on Women Students' Interests. The MIT surveys supported the results of the Stanford survey: women reported more difficulty acquiring research skills and less adequate preparation for graduate school than men reported. These surveys also showed that the issues affecting minority, foreign, and women students seem to be related to their differences from the majority: feelings of powerlessness and of increased pressure and isolation. In an encouraging note, the MIT studies showed that departments varied widely in terms of their perceived "hospitality" to women students; this points to the notion that specific measures could be taken within departments to improve the attitudes and expectations of students.

More research is also being done on the undergraduate experience of students who enter college with an interest in the sciences. One study, recently reported by the U-M's Women in Science Program and the Center for the Education of Women, surveyed choice of majors in science, mathematics, and engineering among 420 U-M undergraduates who entered the University in 1983. Like other studies on the gender-related influences on achievement and attrition in the sciences, it too underscores and calls attention to the importance for women of the "affective atmosphere in which learning takes place."

How then can we begin to create an academic atmosphere that is hospitable to young women interested in the sciences, one in which they can not only survive, but thrive? There are a number of ways to think about this and a number of points of possible intervention. As a start, science teaching at the K-12 level must be made more engaging and interesting, and colleges and universities can play a role in this. At the U-M, the Women in Science Program has developed a high school internship program for women students that places high school juniors in the laboratories of University scientists, who also happen to be women, for a six-week period during the summer. A new "Summerscience" program brings 7th-grade girls from throughout the state of Michigan to the campus for a three-week hands-on experience. The program also sends women scientists into junior and senior high schools to serve as role models and to encourage students towards academic achievement. At the same time, more of us have to recognize and respond to discrimination and inequities for women who are already in the work force: issues of pay equity, accessible and adequate child-care, availability of part-time positions, adjustable tenure-track timetables, parental leave, and related concerns. All of these affect career choice and retention and are sharply focused in the demanding scientific disciplines.

But if we hope to encourage more women to pursue work in the sciences, we clearly have to work much harder at the undergraduate and graduate levels, for students who get this far in the pipeline with their interests intact deserve all the help we can give them. We must help break the feedback loop of lowered expectations and lowered self-image that lead to discouragement, loss of motivation, and lowering of career ambitions. Widnall in her address and Elizabeth Ivey in an article in the AAAS's *Issues in Science and Technology* suggest that this loop can be broken by constant, conscious awareness and interaction on the part of faculty, administrators, and students. How? As a start, those who want to make a difference can take a number of steps:

1. Provide women students with role models, in classrooms and textbooks, and expose them at an early stage to the many career options available in scientific and technical areas and to the varied and acceptable routes women have taken in their careers as scientists.

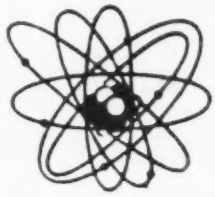
2. Give students access to role-playing experiences designed to enhance self-confidence and build independence—

offer support to young women to stay in a field where women make up only 11 percent of university science professors. Funds for the program, which will be offered again this summer, come from the National Science Foundation. Women are turned off—and out of—science for a variety of reasons, Davis says, including a lack of role models, a lack of career information, little hands-on experience, and persistent sex-stereotyping in junior and senior high years.

During the program, each young woman was presented an analog digital converter designed by Carl F. Berger, professor of education and director of the Office of Instructional Technology. The instrument converts signals from instruments like thermometers and scales so computers can process them and graph them on the screen. For instance, the students measured the heat in a cup of coffee before and after adding cream, and then, using the converter, graphed their findings on a Mac PC.

"The analog converters were theirs to take back with them," Davis said, "where they will donate them to science teachers at school. The girls will install them, explain how they work, and become the resident converter experts." The ninth graders also contracted with "Summerscience" to give a 15-minute talk to other students about their experiences.

—Deborah Gilbert



exposure to the so-called "hidden agenda" of the academic or work environment. Some examples:

- —Opportunities to engage in research and to present and defend research results in regular and active seminars and group meetings.
- —Opportunities to evaluate and criticize the work of others, verbally and in groups.

3. Provide all students with opportunities for courses, dialogue, and debate about scientific and technical issues as they relate to societal issues, and to the humanities and social sciences.

4. Address issues of marriage and family as they relate to the career choices and concerns of young women.

5. Publicly challenge colleagues who make inappropriate or prejudicial remarks about women students and their appropriateness to non-traditional careers.

Finally, to guide us, we need to pull away from the lab bench, administrative desk, or wherever we are, to look beyond our particular disciplines at the development of modern science as a knowledge system. We should look at the gender metaphors that have shaped modern science so that the world is often perceived to be divided into two parts: the "knower" (the mind) and the "knowable" (nature). In assigning "mind" a masculine character and "nature" a feminine one, have we not, in effect, characterized scientific and objective thought as masculine? As philosopher of science Evelyn Fox Keller and others have pointed out, the very act by which the knower (male mind) can acquire knowledge—the experimental process—has been genderized. The very thought processes and intellectual postures involved in "knowing"—neutrality, objectivity, separation, power—are vivid images in the scientific milieu. And all of these attributes are traditionally associated with masculinity in our culture.

We no longer openly say that women should not do science, but the language and metaphors we daily use to describe science tend to make women "outsiders." Are we not invoking sexual metaphors when we refer to the most objective sciences as the "hard" sciences (physics and mathematics), as opposed to the "soft" sciences (psychology and even biology)? Is it really complimentary to say of a female science student that she "thinks like a man"? Or does this strike at the heart of her concept of herself as a sexual being?

If we can understand the ways in which science itself has been influenced by unconscious mythology and gender associations, perhaps we can free ourselves of some of the constraints that have made science inaccessible and uncomfortable to so many people. One result might be that science might become more accessible and hospitable to the public, as well.

By broadening the participation of underrepresented groups in science, we can also hope to broaden its scope and the problems with which it concerns itself. Not only does diversity promote intellectual vitality; it also helps protect against the concentration of special interests in science. What I envision is a coming together of disciplines around this effort: those from the traditional sciences and from psychology, sociology, women's studies, the history of science, and philosophy will all contribute to the discourse. If we are to broaden the sciences, it will be through an interdisciplinary approach. New national interest in such an approach is an exciting development that is just getting underway.

Barbara Sloat is assistant research scientist in biology, lecturer in biology in the Residential College, and faculty counselor and former associate director of the Honors Program. She was the founding director of the Women in Science program in the Center for Continuing Education of Women. She currently serves as president-elect of the Executive Board of the American Association for Women in Science.

"Perspectives on Women and the Sciences" was originally presented as a talk at Denison University upon receipt of the Grace Lyon Alumnae Award (October 1988) for "her outstanding contributions to the advancement of women in science."

Readers wishing more information concerning books and articles about women and science may write *LSAmagazine* requesting a bibliography.

Perspectives on Women and the Sciences ***LSAmagazine*, Spring 1990**
Barbara Furin Sloat

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